Change claims 1, 10, 19 and 28 -- and add new claims 33 through 72 -- all to read as indicated below.

A1

1. (amended) An imaging system for forming an image of a section of a turbid medium together with objects therein, said system comprising:

laser means for projecting [generating] a pulse beam [substantially uniform in intensity] to illuminate a thin segment [slice] of such [said] turbid medium;

a streak tube, having a [wide but usable] cathode, for generating a two-dimensional optical signal;

a field-limiting slit disposed in front of said cathode for rejecting multiply reflected light;

optical means disposed in front of said field-limiting slit for imaging a reflected portion of said pulse beam on said field-limiting slit;

two-dimensional detector means operatively connected to said streak tube for detecting said two-dimensional signal; and

means for generating a volume display of said medium utilizing all, or substantially all, of the reflected portion of said pulse beam; and

a diamond-arrangement mirror beam inverter that uses the Gaussian beam-shape properties of the pulse beam to enhance outer portions of the pulse beam.

2\. ~~10.~~ (amended) A method for detecting a target in a turbid medium, said method comprising the steps of:

A2

generating a pulse beam [substantially uniform in intensity] and illuminating a thin slice of such [said] turbid medium utilizing the [said] pulse beam, including utilizing a diamond-arrangement mirror beam inverter that uses the Gaussian beam-shape properties of the pulse beam to enhance outer portions of the pulse beam;

generating a two-dimensional signal with a streak tube having a cathode;

rejecting multiply reflected light utilizing a field-limiting slit disposed in front of the [said] cathode;

imaging a reflected portion of the [said] pulse beam on the [said] field-limiting slit utilizing a light-collecting optical means disposed in front of the [said] field-limiting slit;

detecting the [said] two-dimensional signal generated by the [said] streak tube utilizing a two-dimensional detector operatively connected to the [said] streak tube; and

generating a volume display of the [said] medium utilizing all, or substantially all, of the reflected portion of the [said] pulse beam.

3. ~~19.~~ (amended) A system for detecting a target in a turbid medium, comprising:

source means for generating a series of narrow, fan-shaped, pulse beams [substantially uniform in intensity] to illuminate sections of the [said] turbid medium;

A35 Cont

a streak tube comprising:

a [very wide and narrow] photocathode for collecting [the maximum amount of] reflected portions of the [said] pulse beam and in response thereto emitting a corresponding flow of [for converting said reflected portions to] photoelectrons;

a pair of deflection electrodes for generating a deflection electric field, the [said] deflection electrodes being adapted to deflect the [said] photoelectrons emitted from said photocathode; and

a phosphor layer for receiving the [said] deflected photoelectrons and in response thereto emitting a corresponding flow of [converting said deflected photoelectrons to] photons; and

means for applying a varying voltage to the [said] deflection electrodes to cause the [said]

photoelectrons from the [said] photocathode to move rapidly across the [said] phosphor layer, thus converting a temporal variation in the input signal into a spatial variation at the phosphor to create a two-dimensional signal utilizing all, or substantially all, of the reflected portions at the [said] phosphor layer;

A3 Concl'd

detector means operatively connected to the [said] phosphor layer for detecting the [said] two-dimensional signal; [and]

a field-limiting slit for removing multiply scattered light;

optical means for collecting and imaging the reflected portions on the [said] field-limiting slit; [and]

means for generating a volume display of the [said] turbid medium in depth utilizing all, or substantially all, of the reflected portions of the [said] pulse beam; and

a diamond-arrangement mirror beam inverter that uses the Gaussian beam-shape properties of the pulse beam to enhance the outer portions of the pulse beam.

4\. ~~28.~~ (amended) An [The] imaging system for detecting a target in a turbid medium, [claimed in claim 19, further] comprising:

A4 Cont.

source means for generating a series of narrow, fan-shaped, pulse beams to illuminate sections of the turbid medium;

a streak tube comprising:

a photocathode for collecting reflected portions of the pulse beam and in response thereto emitting a corresponding flow of photoelectrons;

a pair of deflection electrodes for generating a deflection electric field, the deflection electrodes being adapted to deflect the photoelectrons emitted from said photocathode; and

a phosphor layer for receiving the deflected photoelectrons and in response thereto emitting a corresponding flow of photons; and

means for applying a varying voltage to the deflection electrodes to cause the photoelectrons from the photocathode to move rapidly across the phosphor layer, thus converting a temporal variation in the input signal into a spatial variation at the phosphor to create a two-dimensional signal utiliz-

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ing all, or substantially all, of the reflected portions at the phosphor layer;

A4 Concld

detector means operatively connected to the phosphor layer for detecting the two-dimensional signal;

a field-limiting slit for removing multiply scattered light;

optical means for collecting and imaging the reflected portions on the field-limiting slit;

means for generating a volume display of the turbid medium in depth utilizing all, or substantially all, of the reflected portion of the pulse beam;

a second photocathode for receiving [converting] photons emitted from the [said] phosphor and in response thereto emitting a corresponding flow of photoelectrons; and

a microchannel plate intensifier for increasing the gain of photoelectrons emitted from the [said] second photocathode; and

a second phosphor layer for receiving [converting] photoelectrons emitted from the [said] microchannel plate intensifier and in response thereto emitting a corresponding flow of photons, wherein the [said] second phosphor is coupled to the [said] detector means.

SUB B1

33. An imaging system for forming an image of a thin section of a turbid medium with objects therein, said system comprising:

A5 Cont.

means for projecting a pulsed thin-fan-shaped beam to selectively illuminate, along an illumination-propagation direction, a thin section of such turbid medium;

a streak tube, having a cathode for receiving reflected light back, approximately along the illumination-propagation direction, from the thin section of turbid medium; said streak tube also having an anode end, and comprising:

first electronic means for forming at the anode end of the streak tube successive thin-strip-shaped electronic-image segments of the light successively received on the cathode from the illuminated turbid-medium thin section, and

second electronic means for distributing the successive thin-strip-shaped electronic-image segments, along a direction generally perpendicular to a long dimension of the image segments, across the anode end of the streak tube,

said distributing of the electronic-image segments being in accordance with elapsed time after operation of

A5 Cont

the beam-projecting means so that each thin-strip-shaped electronic-image segment is displaced from a side of the anode end of the tube substantially in proportion to total propagation distance and time into and out from the turbid-medium thin section, to form a composite electronic image of the turbid-medium thin section as a function of propagation depth.

6. ~~34.~~ The imaging system of claim 5 ~~33~~, wherein:

the beam penetrates the thin section during a first range of times corresponding to beam propagation depth into the thin section;

A5 Cont.

the cathode receives the reflected light during a second range of times corresponding to total propagation distances into and out from the thin section approximately along the illumination-propagation direction; said second range of times being substantially equal to propagation times within the thin section plus a substantially fixed delay substantially related to propagation times to and from the thin section;

said first electronic means forming the electronic-image segments at particular times corresponding to the particular total propagation distances for particular penetration depths; and

said second electronic means distributing the electronic-image segments in accordance with the second range of times corresponding to total propagation distances into and out from the thin section.

7. ~~35.~~ The imaging system of claim 5 ~~33~~, further comprising:

electrooptical means for receiving the electronic-image segments and in response producing corresponding optical-image segments to display a composite optical image.

SUB B3

36. An imaging system for forming an image of a thin section of a turbid medium with objects therein, said system comprising:

A5 Cont.

means for projecting a pulsed thin-fan-shaped beam to selectively illuminate, along an illumination-propagation direction, a thin section of such turbid medium; said beam penetrating the thin section during a first range of times corresponding to beam propagation depth into the thin section;

a streak tube, having a cathode for receiving reflected light back, approximately along the illumination-propagation direction, from the thin section of turbid medium during a second range of times corresponding to total propagation distances into and out from the thin section approximately along the illumination-propagation direction; said streak tube also having an anode end, and comprising:

first electronic means for forming at the anode end of the streak tube successive thin-strip-shaped electronic-image segments of the light successively received on the cathode from the illuminated turbid-medium thin section, at particular times corresponding to the particular total propagation distances for particular penetration depths, and

A5 Cont.

second electronic means for distributing the successive thin-strip-shaped electronic image segments, along a direction generally perpendicular to a long dimension of the images, across the anode end of the streak tube in accordance with said second range of times corresponding to total propagation distances into and out from the thin section of turbid medium, to form a composite electronic image of the turbid-medium thin section as a function of propagation depth.

19. ~~37.~~ The imaging system of claim ~~36~~ 18, further comprising:

electrooptical means for receiving the electronic-image segments and in response producing corresponding optical-image segments to display a composite optical image.

SUB B4

38. The system of claim 37, further comprising:

means for displacing the beam-projecting means and streak tube together, along a direction generally perpendicular to a long dimension of the thin section of turbid medium, while sequentially operating the beam-projecting means to project a sequence of beam pulses to illuminate successive thin sections, and generate a corresponding sequence of composite electronic and optical images; and

A5 Cont

means for visually displaying the sequence of said optical images to show a motion picture that emulates visual perceptions of travel through the successive thin sections of turbid medium.

39. The system of claim 37, further comprising:

means for displacing the beam-projecting means and streak tube together, along a direction generally perpendicular to the illumination-propagation direction, while sequentially operating the beam-projecting means to project a sequence of beam pulses to illuminate successive thin sections and generate a corresponding sequence of composite electronic and optical images; and

means for visually displaying the sequence of said optical images to show a motion picture that emulates visual perceptions of travel through the successive thin sections.

SUB B6

A5 Cont.

40. The system of claim 39, further comprising:

means for roughly compensating for geometrical effects that systematically vary the intensity of reflected light, along the long dimension of the thin section of turbid medium.

26 ~~41.~~ The imaging system of claim 18 ~~36~~, wherein:

the beam-projecting means comprise means for projecting the pulsed beam with very short duration, and substantially in the shape of a line that is extended perpendicular to the illumination-propagation direction, to selectively illuminate a succession of substantially line-shaped thin shallow volumes of the turbid ocean-volume ~~medium~~ thin section at successive propagation depths respectively; and

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said streak-tube cathode receives the reflected light successively from said succession of substantially line-shaped thin shallow volumes, respectively.

~~42.~~ The system of claim 41, further comprising:

an optical focal element interposed in front of the streak-tube cathode, for imaging onto the cathode light reflected from the turbid-medium thin section; and wherein

the cathode receives the reflected light in the form of a succession of thin-strip-shaped images of the succession of illuminated substantially line-shaped thin shallow turbid-medium volumes, respectively; and

the first electronic means form the successive thin-strip-shaped electronic-image segments, at the anode end of the streak tube, as electronic images of the succession of thin-strip-shaped cathode images.

43. The system of claim 42, further comprising:

means for roughly compensating for geometrical effects that systematically vary the intensity of reflected light, along a long dimension of the thin-strip-shaped images on the cathode.

A5 Cont.

44. The system of claim 41, wherein:

the beam-projecting means comprise means for projecting the pulsed beam to penetrate the turbid-medium thin section to reach a substantially light-impenetrable surface beyond the thin section;

said surface having a surface relief that comprises plural levels of ~~said~~ light-impenetrable surface, successively encountered by each beam pulse in propagating along the illumination-propagation direction; and

the second electronic means form said composite image including a profile of the light-impenetrable surface relief;

wherein said extremely short duration facilitates spatial resolution of relatively shallow features within said surface relief.

A5 Cont

45. The system of claim 41, wherein:

said illumination-propagation direction is substantially in a radially diverging pattern, diverging radially from the beam-projecting means;

each substantially line-shaped beam pulse has the shape of a circular segment, with the beam-projecting means substantially at the center; and

the cathode receives the reflected light back approximately along the same radial pattern, but converging.

46. The system of claim 36, further comprising:

a field-limiting slit for isolating, within the light imaged onto the cathode, said back-reflected light approximately along the illumination-propagation direction;

thereby substantially excluding light reflected along other directions.

47. The system of claim 36, further comprising:

means for enhancing the composite image at the anode end of the streak tube.

27. ~~48.~~ The system of claim 18 ~~36~~, wherein:

the first electronic means operate over a range of times beginning substantially with receipt of reflection from the surface of the turbid ocean volume ~~medium~~ thin section; and

the second electronic means operate over substantially the same range of times to form the composite image extending from a line that represents the surface of the turbid ocean volume ~~medium~~ thin section toward lines representing the interior of the turbid ocean volume ~~medium.~~

28. ~~49.~~ The system of claim 18 ~~36~~, wherein:

the first electronic means operate over a range of times ending substantially with receipt of optical information by the system indicating that a limit of penetration depth has been reached; and

the second electronic means operate over substantially the same range of times to form the composite image from lines representing the interior of the turbid ocean volume ~~medium~~ thin section to a line representing the limit of propagation depth.

A5 Cont.

~~50.~~ 29. The system of claim ~~36~~ 18, wherein:

the beam-projecting means comprise means for projecting the pulsed beam to penetrate the turbid ~~medium~~ ocean volume thin section to reach a substantially light-impenetrable surface beyond the turbid ~~medium~~ ocean volume thin section;

said surface having a surface relief that comprises plural levels of said light-impenetrable surface, successively encountered by the pulsed beam in propagating along the illumination-propagation direction; and

the second electronic means form said composite image including a profile of the light-impenetrable surface relief.

~~51. The system of claim 50, wherein:~~

~~the streak tube cathode successively receives reflected light back, approximately along the illumination-propagation direction, from the plural levels of the light-impenetrable surface, respectively.~~

A5 Cont

52. The system of claim 36, wherein:

the first electronic means operate over a range of times beginning substantially with receipt of reflection from the surface of the turbid-medium thin section, and ending substantially with receipt of optical information by the system indicating that a limit of penetration depth has been reached; and

the second electronic means operate over substantially the same range of times, so that the composite image extends from a line representing the surface of the turbid-medium thin section to a line representing the limit of propagation depth.

53. The system of claim 52, wherein:

the limit of penetration depth is a substantially light-impenetrable surface beyond the turbid-medium thin section.

54. The system of claim 36, further comprising:

means for enhancing the composite electronic image at the anode end of the streak tube;

said enhancing means comprising electronic means for amplifying electron flow, within the streak tube, that creates the composite image.

30. ~~55.~~ The system of claim 18 ~~36~~, further comprising:

A5 B Cont

means for roughly compensating for geometrical effects that systematically vary the intensity of reflected light along the long dimension of the thin section of turbid ocean volume ~~medium~~;

said roughly-compensating means comprising optical means for generally reversing the relative intensities of (1) the light projected near ends of the thin-fan-shaped beam with respect to (2) the light projected near the center of the thin-fan-shaped beam.

SUB C7

56. The system of claim 36, further comprising:

means for displacing the beam-projecting means and streak tube together, along a direction generally perpendicular to a long dimension of the thin section of turbid ocean volume ~~medium~~, while sequentially operating the beam-projecting means to project a sequence of beam pulses to illuminate successive thin sections of turbid ocean volume ~~medium~~, and generate a corresponding sequence of composite electronic images; and

A5 Cont

B

B

means for using the sequence of composite electronic images as an emulation of video data recorded in travel through the successive thin sections of turbid ocean volume ~~medium~~; said using means comprising means selected from the group consisting of:

B

means for using the sequence of composite electronic images to display a video sequence that emulates visual perceptions of travel through the successive thin sections of turbid ocean volume ~~medium~~, and

B

means for recording the sequence of composite electronic images to be used later in displaying such a video sequence.

57. The imaging system of claim 36, further comprising:
electron-sensitive, spatially discriminating means for receiving the successive thin-strip-shaped electronic-image segments and in response generating a flow of photons to produce corresponding optical-image segments.

A5 Cont

58. The system of claim 57, further comprising:
means for enhancing the composite optical image;
said enhancing means comprising electrooptical means for amplifying said flow of photons generated by the electron-sensitive means.

59. The imaging system of claim 58, wherein:
the electron-sensitive means comprise a phosphor screen that displays the composite optical image.

60. The imaging system of claim 59, wherein:
the phosphor screen is disposed across the anode end of the streak tube.

61. The imaging system of claim 59, wherein:

the electrooptical means comprise video means for recording and reproducing the composite optical image displayed by the screen.

A5 Cont

~~62.~~ 36. The imaging system of claim ~~36~~ 18, further comprising:

a detector array for receiving the composite electronic image and in response producing a corresponding data array; and

data-array utilization means selected from the group consisting of:

a video display for receiving the data array and in response displaying a corresponding optical image, and

means for recording the data array to be displayed later.

~~63.~~ The imaging system of claim 36, wherein:

the beam-projecting means comprise a laser.

SUB B8

64. An imaging system for forming an image of a thin section of a turbid medium with objects therein, said system comprising:

means for projecting a pulsed thin-fan-shaped beam to selectively illuminate a thin section of such turbid medium;

a streak-tube cathode for receiving reflected light back, approximately along the illumination-propagation direction, from the thin section of turbid medium;

means for focusing the reflected light onto the streak-tube cathode substantially directly;

said focusing means comprising (1) no image slicer, and (2) no pixel-encoding fiber bundle, and (3) no other image-remapping device; and

streak-tube means, responsive to the focused reflected light, for forming therefrom a corresponding composite electronic image of the turbid-medium thin section as a function of propagation depth.

~~65.~~ 39. The imaging system of claim ~~64~~ 38, further comprising:

electrooptical means for receiving the composite electronic image and in response producing corresponding optical-image segments to display a composite optical image.

SUBC10

B5 Cont.

66. The system of claim 65, further comprising:

means for displacing the beam-projecting means and streak-tube means together, along a direction generally perpendicular to a long dimension of the thin section of turbid ocean-volume ~~medium~~, while sequentially operating the beam-projecting means to project a sequence of beam pulses to illuminate successive thin sections of turbid ocean-volume ~~medium~~, and generate a corresponding sequence of composite electronic images;

whereby the electrooptical means produce a corresponding sequence of composite optical images; and

means for displaying the sequence of composite optical images to show a motion picture that emulates visual perceptions of travel through the turbid ocean-volume ~~medium~~ thin section.

SUB B9

A5 Cont

67. A method of imaging a turbid medium with objects therein, said method comprising the steps of:

projecting a pulsed thin-fan-shaped beam to selectively illuminate, along an illumination-propagation direction, a thin section of such turbid medium;

then at a substantially common location with the projecting step, receiving reflected light back, approximately along the illumination-propagation direction, from the thin section of turbid medium;

forming successive thin-strip-shaped image segments of the reflected light successively received along approximately the illumination-propagation direction;

distributing the successive thin-strip-shaped image segments, along a direction generally perpendicular to a long dimension of the images;

said distributing of the image segments being in accordance with elapsed time after the beam-projecting step so that each thin-strip-shaped image segment is displaced from a common baseline position substantially in proportion to total propagation distance and time into and out from the medium, to form a composite image of the turbid-medium thin section as a function of propagation depth;

after the projecting and receiving steps, shifting said common location in a direction substantially at right angles

to both (1) a long dimension of the thin-fan-shaped beam and (2) the illumination-propagation direction;

repeating all of the above steps multiple times, with at least the projecting, receiving and shifting steps in the indicated order, to form multiple composite images of progressively encountered turbid-medium thin sections as a function of propagation depth.

42. ~~68.~~ The method of claim ~~67~~ 41, further comprising:

displaying the sequence of composite images in human-visible form, as a motion picture that emulates visual perceptions of travel through the turbid ~~medium~~ ocean-volume.

43. ~~69.~~ The method of claim ~~67~~ 41, wherein:

the image-segment forming step is at least in part an electronic step, and the successive thin-strip-shaped image segments of the reflected light are electronic image segments; and

the distributing step is at least in part an electronic step.

A5 Cont.

~~70.~~ 44. The method of claim ~~69~~ 43, wherein:

the successive thin-strip-shaped image segments are distributed by deflection of an electron beam forming said electronic images.

~~71.~~ 45. The method of claim ~~67~~ 41, particularly for use with substantially thin-strip-shaped light-sensitive photoelectronic means, and wherein the image-segment forming step comprises:

optically focusing said received light, reflected from the thin-fan-shaped beam, onto the substantially thin-strip-shaped light-sensitive photoelectronic means so that intensity variations along the reflection of the thin-fan-shaped beam, within said focused light, are arrayed along the photoelectronic means; and

response of the photoelectronic means to said received reflected light by generation of a corresponding substantially unidimensional electronic signal array, wherein electronic signal variations along the array correspond to said intensity variations of the focused light along the photoelectronic means;

whereby said successive thin-strip-shaped image segments take the form of successive substantially unidimensional electronic signal arrays.

A5 Concl'd

46. ~~72.~~ The method of claim 45 ~~71~~, wherein:

the distributing step comprises applying the successive substantially unidimensional electronic signal arrays to control successive optical-image lines of a two-dimensional display device, to construct said composite image of the turbid ocean-volume ~~medium~~ thin section as a function of propagation depth.

IN THE DISCLOSURE:

Please change the title of the application to read thus: --UNDERWATER IMAGING IN REAL TIME, USING SUBSTANTIALLY DIRECT DEPTH-TO-DISPLAY-HEIGHT LIDAR STREAK MAPPING-- .

In the Abstract of the application at line 12, please change "optic" to: --optical element-- .

~~On page 19 at line 13, please change equation (1) to read in its entirety as set forth below. (Please note that for clarity funny quotes have been omitted from this expression.)~~

88P 5/23/95

$$\cancel{E = \pi B (n.a.)^2 A \qquad (1)}$$

On the same page at line 15, change the minus sign "-" to a multiplication symbol --•-- .

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